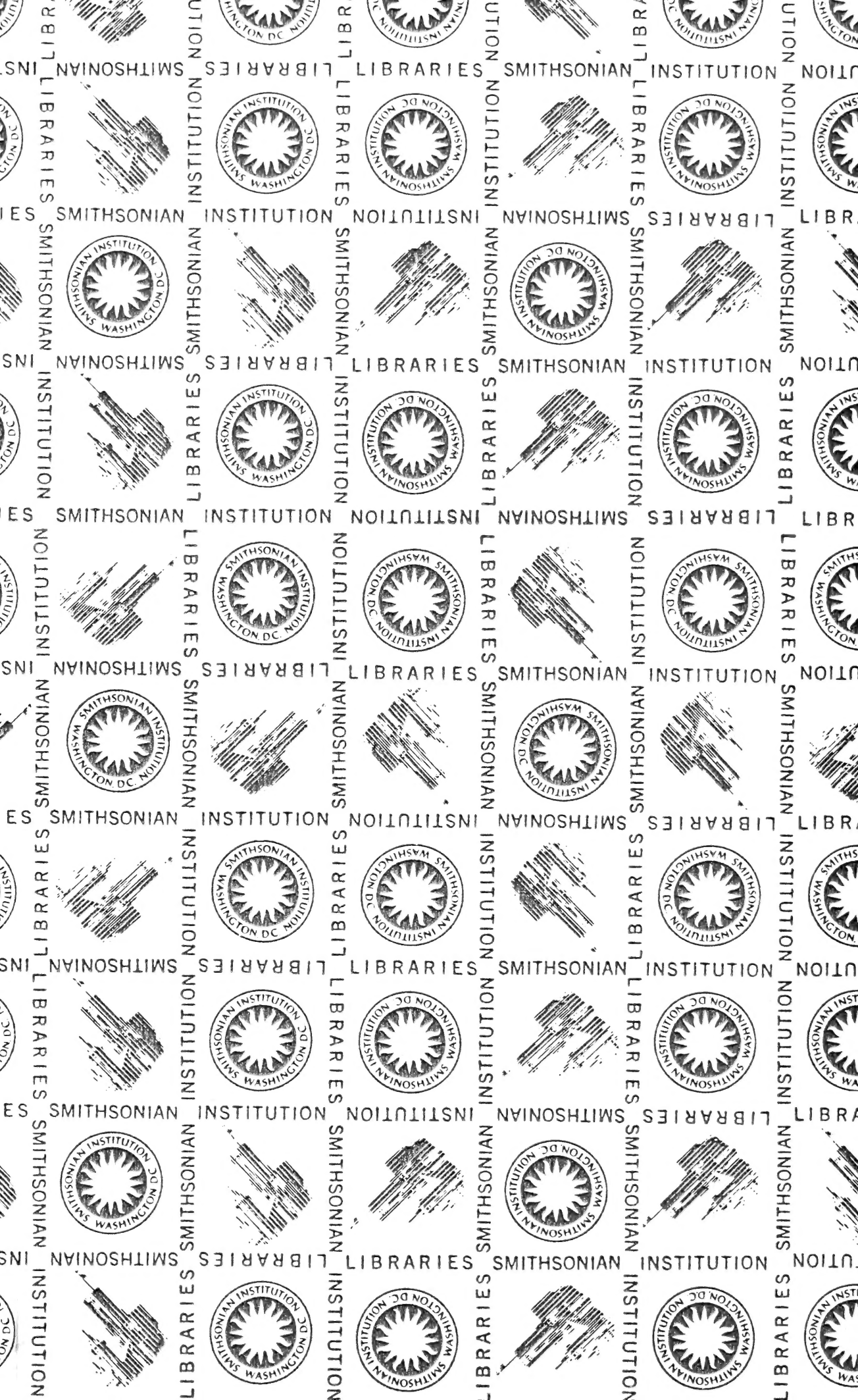
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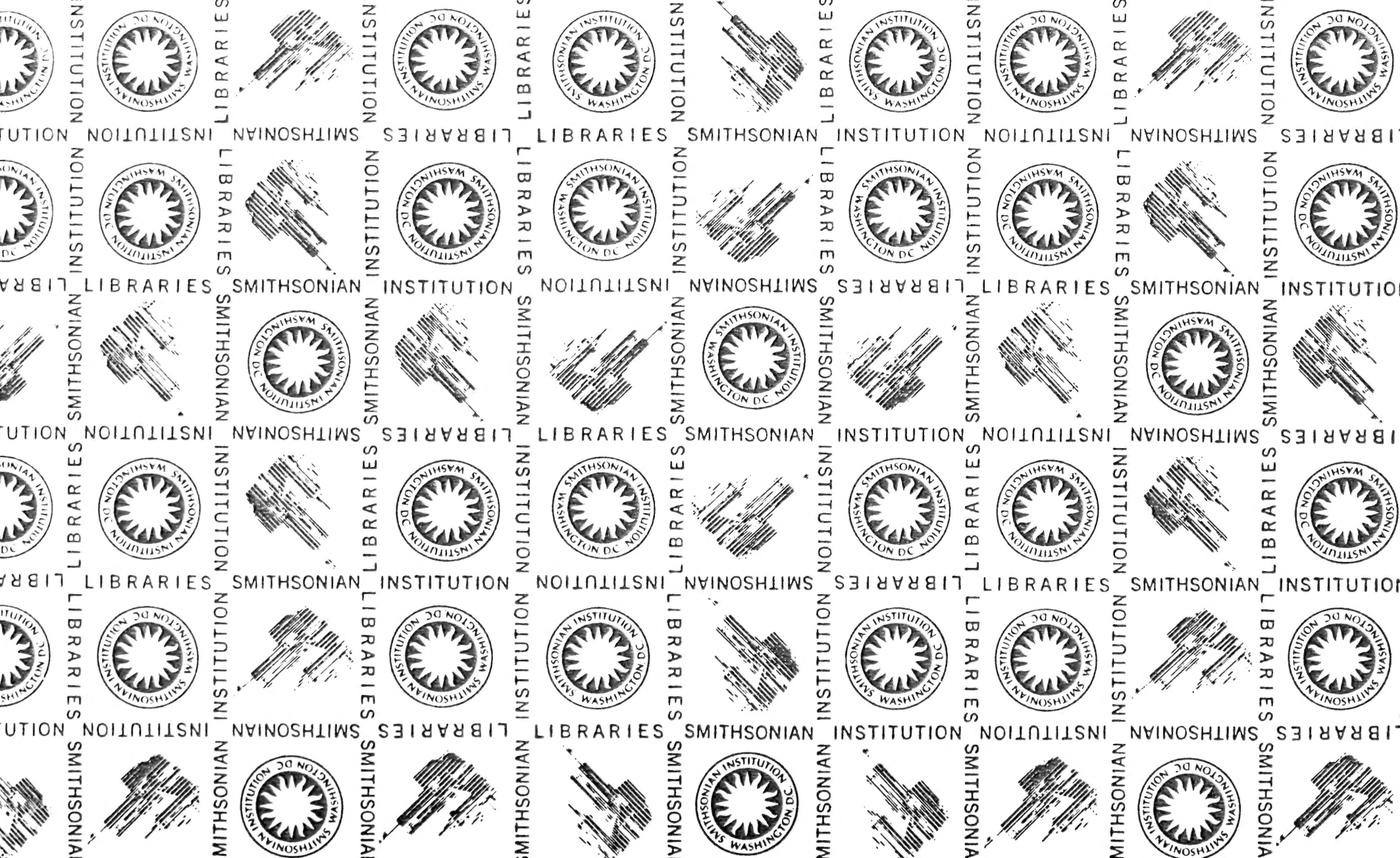
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BUREAU OF FISHERIES

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CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS AND BARREN BOTTOMS OF MISSISSIPPI EAST OF BILOXI

By H. F. MOORE

Assistant in Charge of Scientific Inquiry

Bureau of Fisheries Document No. 774

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

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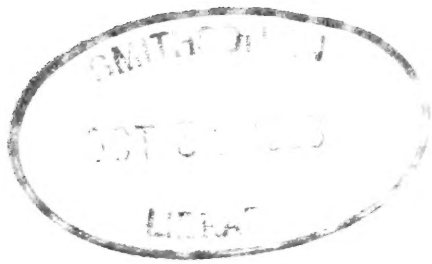

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By H. F. Moore,
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INTRODUCTION.

This investigation was made at the request of Hon. E. J. Noel, Governor of Mississippi, in connection with a similar survey in Alabama which already had been provided for. Had not the latter been in progress it is probable that work would have been conducted near the western end of Mississippi Sound, where the natural beds are more extensive and productive, but the economy in time effected by the contiguity of the two areas to be surveyed was a controlling factor in deciding the locus of the Mississippi investigations.

There are extensive oyster interests within the area embraced by the survey, but the beds upon which they depend are principally near the western limits of the State. Formerly the largest quantity and the best quality of the oysters used in the canning and shucking houses of Mississippi came from Louisiana, but legislation in that State has placed impediments on the export of oysters to be canned or shucked in other States, with the result that the Mississippi industry has been more or less seriously handicapped for lack of proper raw material. A limited quantity of oysters is brought from Alabama for packing, principally at Biloxi.

The triangulation on which the survey was based was furnished for the purpose by the United States Coast and Geodetic Survey, and is therefore accurate. All of the points established, excepting buildings and other structures of like character, are marked by substantial concrete monuments. Should Mississippi establish a system of leasing her barren bottoms for purposes of oyster culture these stations will furnish an invaluable basis for the survey of the leaseholds. With the reference points which they furnish it will be possible to measure the areas accurately and to locate the corners in a manner which will make impossible disputes between contiguous holders and between the lessees and the State. In all States in which oyster culture has been long established the importance of being able to refer the water surveys to permanent and accurately determined points on shore is recognized as necessary to prevent litigation, fraud, and loss to the State, and in many cases the States have been impelled to establish such marks at much expense to themselves. The survey of the actual oyster beds and the barren bottoms was conducted by the Bureau of Fisheries in February and March, 1911. The work consisted of the determination

of the location and extent of the oyster beds by means of biological and hydrographic examinations and investigation of the character of the barren bottoms in respect to their suitability for purposes of oyster culture. No previous investigation of this character has been made in the region covered by the survey, and there is therefore nothing on which to base comparisons with past conditions, and no way in which to determine to what extent changes in the beds have been effected by the oyster fishery or variations in the physical characteristics of the waters and the adjacent land.

METHODS OF THE SURVEY.

The methods employed were those pursued in former surveys of like character, and are explained in detail in a description of the beds of the James River,[a] from which some of the following is repeated:

A "boat sheet" was prepared, on which were accurately platted the positions, as determined by triangulation, of lighthouses, buildings, tripods, etc., used as signals. These data were furnished by the United States Coast and Geodetic Survey.

The oyster beds were discovered by soundings with a lead line, but principally by means of a length of chain dragged over the bottom at the end of a copper wire running from the sounding boat. The wire was wound on a reel and its unwound length was adjusted to the depth of water and the speed of the launch, so that the chain was always on the bottom. Whenever the chain touched a shell or an oyster the shock or vibration was transmitted up the wire to the hand of a man whose sole duty it was to give heed to such signals and report them to the recorder.

The launches from which the soundings were made were run at a speed of between 3 and 4 miles per hour. At intervals of three minutes—in some cases two minutes—the position of the boat was determined by two simultaneous sextant observations of the angles between a set of three signals, the middle one of which was common to the two angles, the position being immediately platted on the boat sheet. At regular intervals of 15 seconds, as measured by a clock under the observation of the recorder, the leadsman made a sounding and reported to the recorder the depth of the water and the character of the bottom, immediately after which the man at the wire reported the character of the chain indications since the last sounding—that is, whether they showed barren bottom or dense, scattering, or very scattering growths of oysters.

With the boat running at 3 miles per hour the soundings were between 60 and 70 feet apart, and, as the speed of the boat was uniform, the location of each was determinable within a yard or two by dividing the platted distance between the positions determined by the sextant by the number of soundings. The chain, of course, gave a continuous

[a] Moore, H. F.: Condition and extent of the oyster beds of James River, Va. Bureau of Fisheries Document No. 729.

indication of the character of the bottom, but the record was made at the regular 15-second intervals observed in sounding.

The chain, while indicating the absence or the relative abundance of objects on the bottom, gives no information as to whether they are shells or oysters, nor, if the latter, their size and condition. To obtain these data it was necessary to supplement the observations already described by others more definite in respect to the desired particulars. Whenever, in the opinion of the officer in charge of the sounding boat, such information was required, a numbered buoy was dropped, the time and number being entered in the sounding book. Another launch, following the sounding boat, anchored alongside the buoy, and a quantity of the oysters and shells were tonged up, separated by sizes, and counted.

This boat at each station made a known number of "grabs" with the oyster tongs, exercising care to clean the bottom of oysters as thoroughly as possible at each grab. In a given depth of water and using the same boat and tongs, an oysterman will cover practically the same area of the bottom at each grab, but, other factors remaining the same, the area of the grab will decrease with an increase in the depth.

Careful measurements were made and tabulated showing the area per grab covered by the tonger employed on the work at each foot of depth of water and for each pair of tongs and boat used. With these data, and knowing the number of "grabs," the number of oysters of each size per square yard of bottom was readily obtainable by simple calculation. The following example will illustrate the data obtained and the form of the record:

DEPARTMENT OF COMMERCE AND LABOR.

BUREAU OF FISHERIES.

Field record of examinations of oyster beds.

General locality, *Mississppi Sound.*
Local name of oyster ground, *Scranton Reef.*
Date, *February 1, 1911.* Time, 2.00 p. m.
Angle, *H 101.* Buoy No. *6.*
Depth, *4.3.* Bottom, *Soft, over 7½″.*
Condition of water, *Thick.*
Density, *1.016.* Temperature, *19.*
Current, Stage of tide, *Flood.*
No. grabs made, *8.* Tongs, *10 feet.*
Total area covered, *2.36* square yards.

No. oysters taken { —1 in., *20.* 1 in.–3 in., *101.* / 3 in.–4 in., *11.* 4 in., *0.* }

Quantity shells, *0.* *8 dead.*

Result { Spat per square yard, *8.3.* / Culls per square yard, *42.2.* / Counts per square yard, *4.6.* }

This furnishes an exact statement of the condition of the bed at the spot, which can be platted on the chart with error in position of not more than a few yards. From the data obtained a close estimate may be formed of the number of bushels of oysters and shells per acre in the vicinity of the examination, and, by multiplying the observations, for the bed as a whole. In the course of the survey 472 observations were made at various places, principally on the natural rocks, but some on the barren bottoms also.

In estimating the productiveness of the bottoms it appeared desirable to use the method employed in Delaware Bay [a] rather than that followed in the James River survey.

Where tongs are used exclusively a bed with a given quantity of oysters lying in shoal water is more valuable commercially than one with the same quantity of oysters in deeper water, owing to the fact that the labor of the tonger is more efficient on the former. As has been pointed out, the area covered by a "grab" decreases with the depth, other factors being the same; and, moreover, the deeper the water the greater is the labor involved in making the grab and the smaller is the number of grabs which can be made in a given time. Where, however, the depth is practically uniform and shoal, as in the region treated in this report, it is unnecessarily refined and laborious to make such allowance for depth, and it is nearly as accurate and satisfactory to rate the bottoms in accordance with an arbitrary standard.

In this report the classification of the relative productiveness of the various beds and parts of beds, as exhibited on the chart and discussed in the text, is as follows:

Dense growth	Bearing over 150 bushels per acre.
Scattering growth	Bearing between 75 and 150 bushels per acre.
Very scattering growth	Bearing between 25 and 75 bushels per acre.
Depleted bottom	Bearing less than 25 bushels per acre.

This classification refers solely to oysters of a size assumed to be large enough for the market, in this case to those 3 inches or more in length, although the cull law of Mississippi permits oysters 2½ inches long to be taken from the public beds. As the classification takes no account of the smaller oysters, certain areas bearing a heavy growth of young may be described and shown on the chart as depleted, owing to the paucity of mature oysters. A case of this character is the depleted part of West Pascagoula, where there are but 3 bushels of market oysters per acre and 279 bushels of small ones. While the charts can not indicate this, the descriptions of the beds show it in all cases. The charts show in general terms the character of the beds in respect to the product available for market, so far as mere size

[a] Condition and extent of the natural oyster beds of Delaware. By H. F. Moore, assistant, United States Bureau of Fisheries. Bureau of Fisheries Document No. 745, 1911.

of the oysters is concerned, at the time of the survey. If the oysters were of ordinarily good condition and shape, which unfortunately in most cases they were not, the areas indicated as bearing dense and scattering growth would yield a product sufficient to make tonging remunerative under the economic conditions existing. Where the market oysters are rated as very scattering, the growth is insufficient to support a fishery at the low price which the product would yield. The depleted bottom is that on which the product of market oysters, at the time of the survey, was very small, and is not necessarily formerly productive bottom now denuded, as might be supposed from a strict definition of the descriptive term employed. On the contrary, it may be formerly barren bottom now coming into production.

The barren bottom, which is that totally devoid of oysters, and in most cases of shells, vastly exceeds the oyster bottom in extent. Its interest in connection with the survey lies in its relative availability for oyster culture; that is, whether or not its general character is such as to enable it to become productive if proper measures to that end be taken. The most important consideration is, usually, the character and degree of stability of its constituent materials. If the bottom be too soft the shells and oysters deposited thereon will soon become engulfed.

In previous surveys the method ordinarily used by oystermen has been employed, the consistency of the bottom being determined by probing with a pole. By noting the resistance which the bottom imposes to the penetration of the probe, the observer forms an opinion of its relative hardness and of its suitability, in that respect, for oyster culture. In many cases different observers will not agree as to the proper term by which to describe the bottom so tested, and it is therefore difficult to convey to another the meaning desired. To overcome this difficulty an instrument[a] has been devised which gives these data mechanically, by measuring the number of inches the bottom is penetrated by a plunger of a constant weight and size falling through a uniform distance. The instrument is used from an anchored boat, from 6 to 10 tests being made at each station. Any readings which are markedly higher or lower than the others are discarded on the assumption that the plunger has fallen into a crab hole or other depression, or that it has encountered a shell or similar accidental obstruction. The average of the remaining depths of penetration, as indicated on the scale of inches inscribed on the rod, is regarded as the measure of the consistency of the bottom.

[a] Illustrated and described in "Condition and extent of the natural oyster beds and barren bottoms of Mississippi Sound, Alabama." By H. F. Moore, Bureau of Fisheries Document No. 769.

The following designations used to indicate the different degrees of hardness, as shown by the instrument, are arbitrary, although based on the terms used by the oyster growers:

Hard	Penetration less than 4 inches.
Stiff	Penetration between 4 and 8 inches.
Soft	Penetration between 8 and 13 inches.
Very soft	Penetration between 13 and 18 inches.
Ooze	Penetration over 18 inches.

These various types of bottom are shown on the chart by means of circles, the relative area of black included within them indicating the relative degree of hardness, as follows: Hard, a black circle; stiff, a black semicircle; soft, a black quadrant; very soft, two crossing diameters; ooze, one diameter.

The bottoms classed as hard and stiff, those in which the plunger will not penetrate more than 8 inches, are suitable for planting without preparation, provided they are not composed of shifting sand. As sand invariably gives a reading of less than 4 inches, and is therefore rated as "hard," it follows that all "stiff" bottom shown on the chart by a black semicircle can be accepted as safe for planting. Part of the hard bottom is composed of mud and part of sand. The former may be accepted without hesitation, but the latter should be examined with respect to its liability to shift. Soft bottom should be planted with care, and toward its upper or less consistent limits may require some preliminary hardening with shells or sand. Very soft bottom and ooze should not be considered, as oysters planted there will sink, and if not killed, as is probable, will be ill shaped and inferior in every respect. The ratings on which the classification is based have been checked by observation on bottoms actually used for oyster culture in Chesapeake Bay.

The instrument employed has been thoroughly tested and is reliable for the purposes of oyster surveys, but there may be errors in cases where hard bottom is overlaid by several inches of soft mud and ooze. Such bottoms are always readily detected by probing with a pole.

During the course of the survey 10,472 soundings were made and 1,826 angles for the position of the boat were taken on lines aggregating a length of 211 miles, over which the chain was dragged continuously. In addition to the soundings and the use of the chain on the beds, oysters were tonged, examined, and counted, and other biological observations were made at 129 places. The barren bottoms were tested with the instrument previously described at 343 places, at each of which from 6 to 10 observations were made. The data of the survey therefore includes upward of 10,000 soundings, 211 miles of continuous chain readings, and 472 special examinations of the bottom and its contents. The whole area covered was about 75,000 acres, of which 1,708 acres were oyster-bearing bottom.

DESCRIPTION OF NATURAL BEDS.

SCRANTON REEF.

Scranton Reef lies in the shallow water west of the mouth of Pascagoula River. It is roughly rectangular in shape, stretching for upward of 1¼ miles in a southwesterly direction from the depleted bottom close to shore to a depth of 3 or 4 feet at its outer edge. Its former natural limits apparently have been greatly extended within a recent period, partly by the ordinary operations of oystering, partly through the agency of gales which have distributed oysters and shells over the surrounding mud and sand and, principally, through planting operations, reported to have been conducted by the State on the originally barren bottom contiguous to the offshore margin of the natural bed.

The original reef, and practically the only part of the present bed which has reef-like characteristics, is a narrow strip of raccoon oysters having a length of about 1¼ miles in an approximately east and west direction, and an average width of about 200 yards. The later natural and artificial accretions to the bed lie north and south of this ridge.

The bed constitutes the largest continuous area of oyster growth in that part of Mississippi covered by the survey, but the oysters at the time of examination were small, rough, and inferior, and there is every reason to believe that that has been their condition for some years. During the time of the survey practically no oysters were taken from the bed.

The area, condition of oyster growth, and estimated content of this bed are shown in the following table:

OYSTER GROWTH ON SCRANTON REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	44	740	278	32,560	12,232	44,792
Scattering	105	447	117	46,935	12,285	59,220
Very scattering	402	206	47	82,812	18,894	101,706
Depleted	262	27	9	7,074	2,358	9,432
Total	813	.....	.....	169,381	45,769	215,150

The dense growth lies in the planted area outside the original reef as an arcuate strip about one-half mile long and 250 yards wide. The depth of water over this is about a foot less than on the adjacent bottom bearing a more scattering growth, and varies from about 2½ feet at the northern to 4 feet at the southern end of the strip. It is

probable that included in this area may be some natural oyster beds or patches, although they may have been reduced to mere areas of hard bottom prior to the time at which they are alleged to have been planted by the State. The shoaling of the water over the strip indicates either this or an extraordinary production after planting. There are very few oysters over 4 inches long on this area and for every oyster 3 inches long or more there are 6 or more under that length, and all are poor in every respect.

South of this strip and continuous with it in a depth of 4 to 5 feet is an area of scattering oysters, but the principal growth of that character lies on the old ridge previously described. On the crest of the ridge the depth is generally 1 foot or less, but the scattering growth passes to a depth of about 2½ feet at the western end in a channel running to one of the bayous. In this area there is hardly an oyster reaching a length of 4 inches and there are nearly nine times as many under 3 inches as over that. This does not mean that there is an enormous production of young, though that is also true, but that the conditions are such as to prevent oysters growing to a large size even though they may attain a considerable age. In most places examined they were densely clustered, though in one or two spots small single oysters are found in considerable numbers. There were some drills and in one or two places considerable algæ or "moss." The very scattering growth which constitutes about one-half of the entire bed lies in the two areas practically surrounding the denser growth. The smaller of the two is inside of the ridge in water not exceeding 2 feet deep. The larger lies outside of the ridge and on all sides of the area of dense growth previously described. In oysters of marketable size, that is those measuring 3 inches or more in length, the productiveness of the two is about equal, but small oysters are in greater abundance in the outer or planted area, especially in that part of it lying west of the dense growth.

The depleted bottom is confined to the northern and eastern borders of the bed. Over the former it is characterized by the clusters of small oysters sparsely scattered, and apparently owes its existence to a set on shells carried from the more productive bottoms by storms.

DETAILS OF EXAMINATION OF SCRANTON REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
845	Feb. 1	4.0	Dense	18.5	87.0	10.8	0	738.5	172.8	911.3
886	Feb. 2	3.5	do	16.0	90.0	24.0	0	742	384	1,126
852	Feb. 1	2.1	Scattering	5.5	97.5	7.5	0	721	120	841
860	do	2.0	do	3.0	141.0	5.0	0	1,008	80	1,088
868	Feb. 2	2.1	do	.3	12.9	6.8	0	92.4	108.8	201.2
883	do	3.3	do	6.0	41.3	12.7	0	333.1	203.2	536.3
884	do	1.5	do	7.7	55.8	5.0	0	444.5	80	524.5
887	do	4.0	do	2.5	9.5	7.0	0	84	112	196
843	Feb. 1	4.3	Very scattering	8.3	42.2	4.6	0	353.5	73.6	427.1
844	do	4.0	do	21.1	23.3	4.4	0	310.8	70.4	381.2
846	do	3.8	do	.0	37.8	2.2	0	264.6	35.2	299.8
851	do	2.8	do	.0	.9	.6	0	6.3	9.6	15.9
853	do	3.1	do	.0	16.6	1.6	0	116.2	25.6	141.8
858	do	3.1	do	.0	4.7	1.9	0	32.9	30.4	63.3
859	do	3.2	do	.0	47.5	2.9	0	332.5	46.4	378.9
869	Feb. 2	2.0	do	.5	75.0	2.0	0	528.5	32	560.5
870	do	2.0	do	2.9	24.8	4.2	0	193.9	67.2	261.1
874	do	4.0	do	10.7	4.4	1.9	0	105.7	30.4	136.1
878	do	4.0	do	20.5	13.5	2.0	0	238	32	270
879	do	3.5	do	4.1	2.7	2.3	0	47.6	36.8	84.4
880	do	4.0	do	5.5	1.0	1.5	0	45.5	24	69.5
881	do	2.0	do	6.8	56.8	1.9	8	445.2	30.4	475.6
882	do	4.0	do	6.5	21.0	4.5	0	192.5	72	264.5
885	do	2.8	do	2.5	5.4	4.2	0	55.3	67.2	122.5
888	do	2.3	do	7.8	86.6	2.2	0	660.8	35.2	696
889	do	1.5	do							
890	do	2.6	do	1.9	15.9	1.1	5	124.6	17.6	142.2
894	do	3.0	do	.4	20.4	7.2	0	145.6	115.2	260.8
895	do	2.0	do							
896	do	1.0	do	.3	4.4	3.3	0	32.9	52.8	85.7
897	do	1.3	do							
898	do	3.0	do	.0	14.2	4.6	0	99.4	73.6	173
806	Jan. 31	4.0	Depleted	.0	1.1	.0	0	7.7	.0	7.7
807	do	4.3	do	.0	.0	.0	0	.0	.0	.0
854	Feb. 1	3.5	do	1.3	7.7	.7	0	63	11.2	74.2
855	do	3.0	do	.0	.6	.3	0	4.2	4.8	9
856	do	3.1	do	.0	10.3	.9	0	72.1	14.4	86.5
857	do	2.2	do	.0	.5	.8	0	3.5	12.8	16.3
865	Feb. 2	2.0	do							
866	do	2.5	do							
867	do	2.0	do	3.2	4.8	1.0	1	56	16	72
871	do	3.1	do	.8	.0	.4	0	5.6	6.4	12
872	do	3.8	do	.0	.5	1.0	1	3.5	16	19.5
875	do	4.3	do	3.3	4.4	.4	0	53.9	6.4	60.3
891	do	3.0	do	.0	3.4	.9	0	23.8	14.4	38.2
893	do	3.0	do	.0	4.7	.0	0	32.9	.0	32.9
899	do	1.8	do							

PATCHES NEAR SCRANTON REEF.

At a distance of a few hundred yards from the western and southwestern margin of Scranton Reef are several small patches of what appears to be a natural growth of oysters. None of these are of material importance and but one examination was made on each, although one or two lines of soundings were carried over them. The areas and productivity of these patches are shown in the table following.

OYSTER GROWTH ON PATCHES NEAR SCRANTON REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scattering	10	207	77	2,070	770	2,840
Very scattering	10	270	36	2,700	360	3,060
Depleted	8	4	3	32	24	56
Total	28	.....	.....	4,802	1,154	5,956

The area of scattering growth, which covers about 10 acres, lies northwest of Scranton Reef proper in the shallow channel running into West Pascagoula River. The larger of the patches of scattering growth and the depleted bottom lie on the eastern edge of the sand spit between Scranton and West Pascagoula Reefs.

The following data are derived from the examination of these patches:

DETAILS OF EXAMINATION OF PATCHES NEAR SCRANTON REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
847	Feb. 1	4.0	Scattering	2.2	27.4	4.8	0	207.2	76.8	284.0
809	Jan. 31	4.0	Very scattering	24.5	43.0	1.5	0	472.5	24.0	496.5
838	Feb. 1	3.5	do	4.3	5.3	3.0	0	67.2	48.0	115.2
837	do	2.5	Depleted	.6	.0	.2	2	4.2	3.2	7.4

WEST PASCAGOULA REEF.

This body of oysters lies on the west side of the sand spit off the mouth of West Pascagoula River, in a depth of water ranging from 2 feet on the eastern and northern edges to about $3\frac{1}{2}$ feet on the west and south. It consists of an area of dense growth almost surrounded by very scattering oysters. The northern third of the bed, although prolific in young, is rated as depleted, owing to the practical absence of oysters over 3 inches long. The oysters on the bed as a whole are undersized and badly clustered.

The following table summarizes the area and conditions of oyster growth:

OYSTER GROWTH ON WEST PASCAGOULA REEF.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	71	1,261	171	89,531	12,141	101,672
Very scattering	119	177	38	21,063	4,522	25,585
Depleted	95	279	3	26,505	285	26,790
Total	285	.....	.....	137,099	16,948	154,047

The area of dense growth, which comprises about one-fourth of the total, undoubtedly represents the original natural growth, the surrounding less prolific area having been stocked by shells and oysters carried onto the mud by storms and waves and the involuntary agency of the oystermen. This part of the reef is extraordinarily productive, bearing an average of upwards of 1,400 bushels per acre, of which, however, the oysters over 3 inches long constitute but 12 per cent in bulk and less than 6 per cent numerically. In other words, for each oyster 3 inches or more in length, there are approximately 17 smaller ones. Several small schooners were tonging on this area at the time of the survey. The area bearing the very scattering growth of market oysters practically surrounds that just described, lying in a depth of from 2 to 3½ feet of water. It contains hardly more than 20 per cent of the quantity of large oysters per acre which occur on the dense area, but as the small oysters are relatively still less abundant those over 3 inches in length comprise about 18 per cent of the total quantity, although numerically they constitute less than 9 per cent.

The depleted bottom which covers the inshore third of the reef is practically devoid of oysters of marketable size, but in the number and quantity of small oysters it excels the area of scattering growth. The few marketable oysters are generally near the inner edge of the bed, where the oyster growth becomes very sparse. Near the outer edge of the area the young oysters are in places exceedingly abundant.

A few scattered clusters lie on the sandy bottom stretching shoreward.

The following table exhibits the results of examinations made at various stations:

DETAILS OF EXAMINATION OF WEST PASCAGOULA REEF.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
824	Feb. 1	2.8	Dense	30.0	198.0	16.7	0	1,596.0	267.2	1,863.2
825	do	2.3	do	26.0	111.0	8.3	3	959.0	132.8	1,091.8
828	do	2.0	do	19.5	156.0	7.0	8	1,228.5	112.0	1,340.5
820	do	4.0	Very scattering	12.5	15.5	1.5	0	196.0	24.0	220.0
821	do	3.5	do	2.3	2.8	2.8	0	35.7	44.8	80.5
822	do	3.2	do	.6	1.8	1.8	0	16.8	28.8	45.6
823	do	3.0	do	1.6	7.2	3.7	0	61.6	59.2	120.8
835	do	1.9	do	9.5	72.5	2.0	0	574.0	32.0	606.0
830	do	2.2	Depleted	4.0	123.0	.0	0	889.0	.0	889.0
832	do	2.2	do	.0	.5	.7	0	3.5	11.2	14.7
833	do	2.0	do	.0	.7	.0		4.9	.0	4.9
834	do	2.2	do	2.9	23.3	.0	1	218.4	.0	218.4

DEER ISLAND, EAST POINT BED.

This bed lies near the mouth of Biloxi Bay, north of the east end of Deer Island, in a depth of water ranging from 3 to 6 or 7 feet. It is over one-half mile long and slightly more than one-third mile wide,

and contains about 106 acres of all degrees of productiveness. Its southwest edge is indeterminate, the oyster growth being continued shoreward to or above low-water mark.

The following table summarizes the area and distribution of oyster growth on this bed:

OYSTER GROWTH ON DEER ISLAND, EAST POINT BED.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	5	134	184	670	920	1,590
Scattering	19	21	94	399	1,786	2,185
Very scattering	35	29	40	1,015	1,400	2,415
Depleted	47	1	7	47	329	376
Total	106			2,131	4,435	6,566

The area of dense growth is a small, narrow patch of not over 5 acres in extent, which is the most prolific part of the bed in both market and small oysters. The oysters are of excellent shape and good quality. The scattering growth occupies the outer edge of the bed in a depth of from 6 to 8 feet. The market oysters vary in quantity in different places between about 75 bushels and 110 bushels per acre, and are similar in shape and quality to those on the area of dense growth, but small ones are much less numerous. The very scattering growth is inshore of the two areas previously described, and covers about 35 acres; and the depleted bottom, which occupies approximately 47 acres, borders the southern and western edges of the bed. The boundaries of this growth are indeterminate on the landward side, as scattered clusters occur in the shallow water to low-water mark or beyond.

This bed, as a whole, produces the best oysters found in Mississippi during the survey. The examinations made gave the data shown in the following table:

DETAILS OF EXAMINATION OF DEER ISLAND, EAST POINT BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1232	Feb. 25	6.5	Dense	4.6	14.6	11.5	0	134.4	184.0	318.4
1227	...do	8.0	Scattering	1.0	4.0	7.0	0	35.0	112.0	147.0
1233	...do	8.0	.....do	.0	.9	4.8	0	6.3	76.8	83.1
1230	...do	6.0	Very scattering	1.4	3.6	2.9	0	35.0	46.4	81.4
1231	...do	6.3	.....do	.0	7.2	2.1	0	50.4	33.6	84.0
1234	...do	5.0	.....do	.0	.0	2.5	0	.0	40.0	40.0
1228	...do	4.5	Depleted	.0	.6	.0	0	4.2	.0	4.2
1235	...do	5.0	.....do	.0	.0	.6	0	.0	9.6	9.6
1236	...do	5.3	.....do							
1237	...do	6.0	.....do	.0	.0	.7	0	.0	11.2	11.2

SMALL PATCHES, BILOXI BAY.

Northwest of the bed just described and stretching as far as the railroad bridge and to the edge of the private bottoms off Red Bluff are a number of patches varying in extent from one-half acre to about 18 acres, aggregating about 73 acres of all degrees of productiveness.

The condition and extent of these fragmentary beds are summarized in the following table:

OYSTER GROWTH ON SMALL PATCHES IN BILOXI BAY.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	5	120	277	600	1,385	1,985
Scattering	7	99	121	693	847	1,540
Very scattering	60	38	40	2,280	2,400	4,680
Depleted	1	33	8	33	8	41
Total	73	.....	.....	3,606	4,640	8,246

The patches bearing dense growth are four or five in number, covering, all told, about 5 acres and individually so small that to show them on the chart it has been necessary to exaggerate their size They bear between 240 and 341 bushels per acre of oysters over 3 inches long, but the stock is so badly clustered and poor as to have small value.

There are two patches of scattering oysters, covering at most about 7 acres, on which the growth resembles that just described, though less abundant. The patches of very scattering growth are more numerous and several of them are of considerable size. The boundaries of one which adjoins the private beds on the northeast side of the bay about $1\frac{1}{4}$ miles below the railroad bridge was not definitely determined, but it is estimated to contain about 18 acres. At the place examined it bore about 50 bushels of 3-inch oysters per acre and about 10 bushels of smaller ones. Another bed of about 7 acres adjoins the northeast corner of the private beds off Deer Island and bears per acre approximately 50 bushels each of oysters over and under 3 inches long.

The most extensive bed of very scattering oysters covers about 29 acres near the middle of the bay. It bears an average per acre of about 40 bushels of each of the two sizes. This bed lies on bottom such as is classed in this report as soft and very soft, and bears the appearance of having been recently established. It is said that the State planted oysters in this vicinity several years ago, and it appears probable that this is the place. The oysters are inferior and in rough clusters.

DETAILS OF EXAMINATION OF SMALL PATCHES, BILOXI BAY.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1153	Feb. 23	5.5	Dense.....	1.3	26.0	21.3	0	191	341	532
1164	...do.....	4.3	.....do.....	.0	11.1	15.0	0	78	240	318
1172	...do.....	6.5	.....do.....	.0	5.4	17.7	0	38	283	321
1173	...do.....	5.3	.....do.....	.7	24.0	15.3	0	173	245	418
1176	...do.....	6.5	Scattering.....	.0	26.4	8.6	0	185	138	323
1218	Feb. 25	8.0	.....do.....	.0	1.7	6.5	0	12	104	116
1166	Feb. 23	5.0	Very scattering...	.0	.6	2.5	0	4	40	44
1170	...do.....	6.3	.....do.....	.0	9.3	2.1	0	65	34	99
1180	...do.....	6.5	.....do.....	.0	5.0	4.3	0	35	69	104
1219	Feb. 25	8.0	.....do.....	1.0	8.3	1.0	0	65	16	81
1220	...do.....	8.0	.....do.....	.3	4.5	2.8	0	37	45	82
1222	...do.....	9.5	.....do.....	.0	1.7	3.0	0	12	48	60
1224	...do.....	8.5	.....do.....	.0	.7	1.8	0	5	29	34
1225	...do.....	7.0	.....do.....	.0	4.0	1.3	0	28	21	49
1226	...do.....	5.5	.....do.....	2.7	10.7	3.3	0	94	54	148
1142	Feb. 23	12.0	Depleted.....	.0	2.0	0	0	14	0	14
1147	...do.....	5.3	.....do.....	.0	7.3	1.0	0	51	16	67

BILOXI BAY BELOW RAILROAD BRIDGE.

This bed begins close to the piers of the railroad bridge and stretches down the middle of the bay southwest of the channel for a distance of about 1½ miles. It has a maximum width of about 600 yards near its middle, tapering toward the ends, and it embraces an area of about 234 acres. At its inner edge, where it runs to, or practically to, the stakes marking the private beds, the water is about 3 feet deep, gradually increasing to from 5 to 7 feet toward the channel. It consists of a long strip of dense and scattering growth, broadly fringed on its southwest side by less prolific bottom and with an interrupted narrow belt of the same character toward the channel.

Its general condition and extent are shown in the following table:

OYSTER GROWTH IN BILOXI BAY BELOW RAILROAD BRIDGE.

Character of oyster growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	34	180	297	6,120	10,098	16,218
Scattering	106	140	122	14,840	12,932	27,772
Very scattering	68	39	54	2,652	3,672	6,324
Depleted	26	163	17	4,238	442	4,680
Total	234	.....	.....	27,850	27,144	54,994

The scattering growth occupies nearly one-half of the total area of the bed as a strip from 100 to 300 yards wide running practically the entire length of the bed. On this area there is an average growth per acre of about 122 bushels of oysters 3 inches or more

in length and a slightly greater quantity of smaller ones. Numerically the small oysters outnumber the larger ones as about 2.6 to 1.

The dense growth occupies a strip nearly a half mile long near the middle of the bed and a small patch at the lower end. On the latter, which covers about 5 acres, the larger oysters are particularly abundant, examination indicating about 416 bushels per acre. On the larger strip, which contains about 29 acres, there are about 235 bushels per acre. Oysters under 3 inches long range at the places examined between 154 and 218 bushels per acre, the average being about 180 bushels. In actual quantity the small oysters are more abundant than on the area of scattering growth, but in numbers relatively to the market oysters they are but half as abundant.

The very scattering growth and the depleted bottom lie on the edges of the bed as transition areas between the more productive and the barren bottoms. The depleted bottom, although unproductive in large oysters at the time of the survey, was well provided with small ones, the average per acre being about 163 bushels. A number of boats were tonging on this bed during the presence of the survey party in the vicinity. The oysters were of inferior quality, clustered and "coony."

DETAILS OF EXAMINATION OF BILOXI BAY BELOW RAILROAD BRIDGE.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1151	Feb. 23	4.0	Dense.....	0.0	24.0	13.5	0	168	216	384
1158	...do....	5.0	.....do.....	1.2	30.0	16.2	0	218	259	477
1168	...do....	5.5	.....do.....	.0	22.0	26.0	0	154	416	570
1139	...do....	7.0	Scattering.....	5.3	28.6	9.3	0	237	149	386
1144	...do....	5.0	.....do.....	.0	21.8	7.5	0	153	120	273
1146	...do....	6.0	.....do.....	.0	8.6	8.6	0	60	138	198
1148	...do....	5.0	.....do.....	.0	9.4	8.1	0	66	130	196
1152	...do....	5.0	.....do.....	.0	33.8	6.2	0	237	99	336
1155	...do....	4.0	.....do.....	.0	16.5	8.0	0	116	128	244
1162	...do....	5.2	.....do.....	.0	15.6	5.6	0	109	90	199
1169	...do....	7.0	.....							
1138	...do....	4.0	Very scattering..	.0	.7	3.7	0	5	59	64
1143	...do....	6.0	.....do.....	.0	8.3	4.4	0	58	70	128
1150	...do....	4.0	.....do.....	.0	14.0	4.5	4	98	72	170
1154	...do....	4.5	.....do.....	3.3	1.1	3.3	0	31	53	84
1156	...do....	4.0	.....do.....	.0	1.0	2.0	0	7	32	39
1163	...do....	4.8	.....do.....	.0	5.0	2.5	0	35	40	75
1145	...do....	4.5	Depleted.....	.0	32.8	1.1	0	230	18	248
1149	...do....	4.0	.....do.....	.5	13.0	1.0	0	95	16	111

BACK BAY, EAST BED.

This bed, covering about 74 acres of bottom of varying productiveness, lies about north of the draw of the Louisville & Nashville Railroad bridge. It is about five-eighths of a mile long and about

one-quarter of a mile at its widest part. It is covered by from 3 to 3½ feet of water, with a somewhat greater depth on the barren bottom immediately adjacent to its borders. The productive bottom occupies the southern half of the bed, where a small number of tongers were at work during the survey. The oysters are badly clustered, sharp-edged, and of a poor quality.

The general condition of the bed is summarized in the following table:

OYSTER GROWTH IN BACK BAY, EAST BED.

Character of growth.	Area.	Oysters per acre		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	29	113	249	3,277	7,221	10,498
Scattering	6	62	88	372	528	900
Very scattering	18	228	56	4,104	1,008	5,112
Depleted	21	47	11	987	231	1,218
Total	74	.....	.....	8,740	8,988	17,728

The area of dense growth covers about 29 acres, on which there are about 249 bushels of oysters over 3 inches long and 113 bushels of smaller ones per acre. Numerically the two classes are practically equal, that is, there is a young oyster for every one above 3 inches long. In some places the bottom is fairly compact and in others the oysters lie on soft black mud with many buried shells. The oysters are generally in large rough clusters.

The scattering growth lies as a narrow strip on the eastern edge of the preceding and covers about 6 acres. The young oysters are more numerous in proportion to the large ones, but both are in smaller quantity than on the dense part of the bed.

On the area of very scattering growth, while the market oysters are less numerous the young are found in greater quantity than on the other parts of the bed. For each oyster over 3 inches long there are more than 9 smaller ones. The clusters contain numerous individuals, and it is apparent that the conditions are such as to retard their growth. The bottom is hard on the surface. The depleted bottom occupies the gradually narrowing northern end of the bed and is deficient in oysters of all sizes.

The following table gives the details of the examination made on the bed:

DETAILS OF EXAMINATION OF BACK BAY, EAST BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911.	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1189	Feb. 24	4.0	Dense	.0	41.5	15.5	0	290.5	248.0	538.5
1190	...do	4.5	.....do	.0	5.5	13.3	0	38.5	212.8	251.3
1191	...do	6.0	.....do	.0	1.4	17.8	0	9.8	284.8	294.6
1188	...do	4.5	Scattering	2.2	6.7	5.5	0	62.3	88.0	150.3
1203	...do	4.0	Very scattering	.0	19.5	3.0	0	136.5	48.0	184.5
1204	...do	4.0	.....do	.0	45.5	4.0	0	318.5	64.0	382.5
1205	...do	4.2	Depleted	.0	13.5	.5	0	94.5	8.0	102.5
1207	...do	3.8	.....do	.0	4.0	.5	0	28.0	8.0	36.0
1208	...do	4.3	.....do	.0	2.8	1.1	0	19.6	17.6	37.2

BACK BAY, WEST BED.

This bed begins about a quarter of a mile nearly west of the draw in the railroad bridge and stretches along the northern edge of the main channel for a distance of about three-fourths of a mile, its northwestern edge adjoining the boundary stakes of the planted beds. The water varies from less than 3 feet near the eastern end of the bed to about 10 feet at the western edge. Among the beds of Biloxi Bay this is distinguished by the abundance of small oysters.

The following table summarizes the areas, character of growth, and general condition of the several parts of the bed:

OYSTER GROWTH IN BACK BAY, WEST BED.

Character of growth.	Area.	Oysters per acre.		Estimated content of oysters.		
		Under 3 inches.	Over 3 inches.	Seed.	Market.	Total.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	29	279	214	8,091	6,206	14,297
Scattering	5	35	136	175	680	855
Very scattering	41	381	55	15,621	2,255	17,876
Depleted	20	14	1	280	20	300
Total	95	.....	.....	24,167	9,161	33,328

The area of dense growth is a narrow strip extending nearly the entire length of the bed and for a considerable part of the distance near its northeast edge, forming a ridge covered by very shallow water. It covers about 29 acres and bears an average per acre of 214 bushels of market oysters and 279 bushels of small ones. There are about three small oysters to each one over 3 inches long. The stock is generally of poor shape and quality and badly clustered. The area of scattering growth lies between the eastern edge of the preceding and the margin of the bed. There is a fair quantity of the larger oysters but a dearth of small ones.

The very scattering growth lies in two areas, one of about 13 acres, occupying the southern margin of the bed adjoining the channel, and the other of about 28 acres at the western end of the bed. The examination of the former indicated about 70 bushels of larger oysters and 183 bushels of smaller ones per acre. The larger area at the western end of the bed has per acre only 50 bushels of oysters over 3 inches, but is much more productive in small ones, especially in that portion which adjoins the dense growth, where examination indicated 1,120 bushels per acre. This prolificness covers but a small area and the production of both large and small oysters decreases toward the boundary stakes of the planted beds.

The depleted bottom, of which there are two areas, shown on the chart, is almost bare. The following examinations were made:

DETAILS OF EXAMINATION OF BACK BAY, WEST BED.

Angle No.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Shells per square yard.	Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.		Seed.	Market.	Total.
	1911	*Feet.*						*Bush.*	*Bush.*	*Bush.*
1193	Feb. 24	3.5	Dense	0	7.7	10.4	0	53.9	166.4	220.3
1196	...do....	10.0	.....do.....	0	65.4	13.6	0	457.8	217.6	675.4
1214	...do....	4.0	.....do.....	0	30.0	22.0	0	210.0	352.0	562.0
1215	...do....	4.0	.....do.....	0	56.5	7.5	0	395.5	120.0	515.5
1192	...do....	4.0	Scattering.....	0	5.0	8.5	0	35.0	136.0	171.0
1194	...do....	3.0	Very scattering..	0	26.2	4.4	0	183.4	70.4	253.8
1197	...do....	6.0	.....do.....	0	160.0	3.6	0	1,120.0	57.6	1,177.6
1198	...do....	4.5	.....do.....	0	12.8	2.2	0	89.6	35.2	124.8
1199	...do....	6.0	.....do.....	0	18.6	3.6	0	130.2	57.6	187.8
1213	...do....	3.8	Depleted.....	1	2.0	.1	0	14.7	1.6	16.3
1216	...do....	5.0	.....do.....	0	1.9	.0	0	13.3	.0	13.3

THE BEDS IN SUMMARY.

The natural oyster beds of Mississippi east of Biloxi are restricted to the waters adjacent to the mouth of the Pascagoula River and Biloxi Bay. The beds of the former locality, of which there are two and some insignificant patches, embrace almost exactly two-thirds of the naturally productive bottom; Scranton Reef, the larger of the beds, comprises nearly one-half of the oyster area of the region surveyed, and West Pascagoula Reef about one-sixth. The two, with the small patches alluded to, cover about 1,126 acres, of which 115 acres have a dense growth of oysters of marketable size, 115 acres a scattering growth, 531 acres a very scattering growth, and 365 acres are so sparsely covered as to be classified as depleted. All of these lie in water not exceeding 5 feet in depth and most of them, especially the more productive parts, are covered by 3 feet or less.

In Biloxi Bay there are four beds of more than insignificant size. The largest of these, covering about 234 acres, lies on the west side below the railroad bridge. The others in the order of their areas

are near the southeastern end of Deer Island, and the western and eastern beds, respectively, above the railroad bridge. In addition there are a number of small patches below the railroad bridge, the largest of which is believed to be a public planted bed. Altogether there are in Biloxi Bay about 582 acres of oyster bottom, of which 102 acres are classed as dense, 143 as scattering, 222 as very scattering, and 115 as depleted. Of the entire area of 1,708 acres of natural oyster bottom located by the survey, 13 per cent is covered by a dense growth of oysters of marketable size, 15 per cent by a scattering growth, 44 per cent by a very scattering growth, and 28 per cent is depleted or very deficient in such oysters.

The following table summarizes the distribution of the oysters on the several beds:

SUMMARIZED STATEMENT OF AREAS OF MARKET OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Scranton Reef	44	105	402	262	813
Patches near Scranton Reef	.....	10	10	8	28
West Pascagoula Reef	71	.....	119	95	285
Deer Island, East Point	5	19	35	47	106
Small patches, Biloxi Bay	5	7	60	1	73
Biloxi Bay, below railway bridge	34	106	68	26	234
Back Bay, east bed	29	6	18	21	74
Back Bay, west bed	29	5	41	20	95
Total	217	258	753	480	1,708

It should be understood that the foregoing classification in respect to relative density of oyster growth is based solely on the quantity of oysters 3 inches or more in length irrespective of the quantity of small oysters present. The classification, furthermore, represents the condition at the time of examination and the several classes may and undoubtedly will undergo redistribution from time to time. The areas of dense growth may become less productive from overfishing or other causes while a heavy set of spat may bring the lower classes into increased productivity and raise them a step higher in the scale. In some cases the number of young oysters on the beds at the time of examination was sufficient to produce this effect in the following year. On the whole, however, the general conditions shown in this report, barring accidents, should be maintained for a period of years. The estimated total content of oysters over 3 inches long on the several parts of the different beds is shown in the table following.

SUMMARIZED CONTENT OF MARKET OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scranton Reef	12,232	12,285	18,894	2,358	45,769
Patches near Scranton Reef	.....	770	360	24	1,154
West Pascagoula Reef	12,141	.....	4,522	285	16,948
Deer Island, East Point	920	1,786	1,400	329	4,435
Small patches, Biloxi Bay	1,385	847	2,400	8	4,640
Biloxi Bay, below railway bridge	10,098	12,932	3,672	442	27,144
Back Bay, east bed	7,221	528	1,008	231	8,988
Back Bay, west bed	6,206	680	2,255	20	9,161
Total	50,203	29,828	34,511	3,697	118,239

Fifty-four per cent, or 63,871 bushels of the larger oysters disclosed by the survey were found in the region adjacent to the mouth of Pascagoula River. Of these, 24,373 bushels were in dense growth, 13,055 bushels scattering, 23,776 bushels very scattering, and 2,667 bushels on the depleted bottom. The remaining 54,368 bushels, constituting about 46 per cent of the total, were in Biloxi Bay, where 25,830 bushels occurred as dense growth, 16,773 bushels as scattering, 10,735 bushels as very scattering, and but 1,030 bushels were on the so-called depleted bottom.

The average product per acre on the beds near Pascagoula River was 221 bushels on the dense, 113 bushels on the scattering, 45 bushels on the very scattering, and 7 bushels on the depleted bottoms.

In Biloxi Bay the averages are 249 bushels per acre on the dense growth, 117 bushels on the scattering, 48 bushels on the very scattering, and 9 bushels on the depleted bottom. It is therefore evident that the oysters on the areas classed as very scattering and depleted are so sparsely distributed that they are at present negligible commercially on account of the time and labor which would be involved in tonging them. About 72 per cent of the oyster producing bottom is, therefore, to be regarded as of no present producing value. The remaining 28 per cent of the area of the beds produces oysters in sufficient quantity to warrant a fishery if size only is considered, but many of the oysters are so badly clustered and so inferior in quality that they have very little value. This is particularly the case on Scranton and West Pascagoula Reefs.

The only good oysters seen in that vicinity were in the deep water of Pascagoula River, where singles and small clusters are taken in limited quantity. In Biloxi Bay not only is the average productiveness of the dense and scattered growth greater, but the areas of these growths are greater in proportion to the total extent of the beds, and the oysters are of somewhat better quality.

The dense and scattered growths, but especially the former, are doubtless somewhat more prolific than is estimated in this report, as where the oysters are very rank the tongs in many cases do not take up all within the extent of the "grab," and as the estimates are based on the area covered by the open tong heads and the number of oysters brought up in a definite number of grabs, there is certainty of an underestimate. On less prolific bottom this error does not occur. It should be stated that the bushel employed, while of the legal dimensions, contains more than the trade bushel, because to secure uniformity of results the oysters are culled into singles or doubles and carefully packed in the measure. It is estimated that it holds, for this reason, 25 to 30 per cent more than when filled in the ordinary way. The small oysters, on which the future of the beds is in large measure dependent, differ from the larger oysters very materially in their distribution, as is shown in the following table:

SUMMARIZED CONTENT OF YOUNG OYSTERS ON PUBLIC BEDS.

Name of bed.	Character of oyster growth.				Total.
	Dense.	Scattering.	Very scattering.	Depleted.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Scranton Reef	32,560	46,935	82,812	7,074	169,381
Patches near Scranton Reef	.....	2,070	2,700	32	4,802
West Pascagoula Reef	89,531	.....	21,063	26,505	137,099
Deer Island, East Point	670	399	1,015	47	2,131
Small patches, Biloxi Bay	600	693	2,280	33	3,606
Biloxi Bay, below railway bridge	6,120	14,840	2,652	4,238	27,850
Back Bay, east bed	3,277	372	4,104	987	8,740
Back Bay, west bed	8,091	175	15,621	280	24,167
Total	140,849	65,484	132,247	39,196	377,776

It will be observed that in the entire region surveyed there is over three times the quantity of small oysters as of large ones, but if the table be subjected to analysis it will be found that they are very unequally distributed between the Pascagoula and Biloxi localities. Of the total 377,776 bushels, 311,282 bushels, or over 82 per cent, are found in the former, and but 66,494 bushels, or less than 18 per cent, in the latter. In the former there is nearly five times the quantity less than 3 inches long that there is of larger ones, while in Biloxi Bay there is but little difference. On Scranton and West Pascagoula Reefs and the adjacent small patches there are averages of 1,061 bushels per acre on the dense growth, 426 bushels on the scattering, 200 bushels on the very scattering, and 92 bushels on what is called depleted bottom. In other words, for every bushel of oysters of market size there are on the dense areas 4.8 bushels of small ones, on the scattering growth 3.8 bushels, on the very scattering growth 4.4 bushels, and on the depleted bottom 13 bushels.

On the beds of Biloxi Bay, taken as a whole, the dense areas contain 184 bushels of small oysters per acre, the scattering 115 bushels, the very scattering 115 bushels, and the depleted 48 bushels. Comparing the quantity of small and large oysters, the areas of dense growth have 0.7 bushel of the former to each bushel of the latter, the scattering growth 1 bushel, the very scattering growth 2.5 bushels, and the depleted bottom 5.6 bushels.

As it requires more small oysters than large ones to make a bushel, and as the value of the small ones depends upon their potentiality to grow into large ones, the proportion between the numbers of small and large is of more importance than the comparison of their quantities. This proportion for each class of growth on each bed is shown in the following table:

NUMBER OF OYSTERS UNDER 3 INCHES LONG FOR EACH ONE OVER THAT LENGTH ON THE SEVERAL BEDS.

Name of bed.	Character of oyster growth.			
	Dense.	Scattering.	Very scattering.	Depleted.
Scranton Reef	6.07	8.70	10.12	7.28
Patches near Scranton Reef	.....	6.16	17.13	3.00
West Pascagoula Reef	16.89	.....	10.70	227.71
Deer Island, East Point	1.67	.50	1.62	.46
Small patches, Biloxi Bay	.99	1.86	2.20	9.30
Biloxi Bay, below railway bridge	1.38	2.62	1.63	22.00
Back Bay, east bed	1.03	1.62	9.28	9.66
Back Bay, west bed	2.98	.59	15.76	40.00

Analyzing this table by regions, it is found that on the beds in the vicinity of Pascagoula River for every oyster 3 inches or more in length there are on the dense growth about 11 small ones, on the scattering 8, on the very scattering 11, and on the depleted bottom 28. Most of these are between 2 and 3 inches long. On the beds in Biloxi Bay there are respectively 1.6 small oysters to each large one on the dense growth, 2 on the scattering growth, 5.3 on the very scattering growth, and 12 on the depleted bottom.

In Biloxi Bay the proportion of small to large oysters is in no way unusual. On the areas of dense and scattering growth the proportions are such as indicate a normal condition of the beds, although there is a deficiency of small oysters on the scattered growth of Deer Island and Back Bay west beds. The high proportion of young on the depleted areas of certain beds is due not to their unusual abundance but to the scarcity of the larger ones with which they are compared, as may be seen by the detailed tables contained in the descriptions of the individual beds.

On the beds at the mouth of Pascagoula River the condition is different. There the small oysters are superabundant almost every-

where. There appear to be three conceivable explanations of this preponderance—(*a*) an extraordinary set of spat in the year preceding the survey following the destruction of the beds by freshets or other causes, (*b*) an unusually heavy set of spat without the destruction of the mature oysters, and (*c*) an average condition with respect to spat production, but general conditions of environment which prevent or retard the normal growth of the oysters.

Judging from the appearance of the reefs and such information as it was possible to obtain concerning their history it appears that the third is the true explanation of the unsatisfactory state of the oysters. While the spatting conditions are good there is apparently a deficiency of the food requisite for the growth and fattening of the dense oyster population. The oysters are crowded in clusters and the individuals are unable to secure the requisite amount of nutriment. The planting of oysters on the bottom adjoining the original bed of Scranton Reef accentuated the trouble and was ill advised. Better success probably would have attended planting in deeper water and where the tidal flow is stronger.

These beds densely crowded with small and inferior oysters are of no immediate commercial value. Apparently their only use is for seed beds from which the small oysters might be transplanted to localities more favorable for growth.

BARREN BOTTOMS.

The area of barren bottoms—that is, those which are not naturally productive of oysters even in small quantities—vastly exceeds that of the natural beds, including in the latter those so-called depleted areas which bear practically nothing. These bottoms are barren, mainly because of one character in which they differ from the productive areas—namely, that they are devoid of shells or other objects lying on the surface. They consist of sand and mud of varying degrees of stability and consistency. Oysters, immediately after they develop from the egg, for a brief period swim or float freely in the water, settling to a fixed condition only after they reach a stage of considerable development.[a]

It is not necessary to give more detail to this subject other than to say that at the time at which they are undergoing fixation the oysters are very minute, and a slight film of mud or slime is sufficient to stifle them. During the spawning season these little organisms are present in the water in untold myriads and are precipitated to the bottom in a continuous gentle drizzle of tiny specks. If they fall on an oyster bed they find firm supports on the shells and oysters, attach themselves and grow, but if they fall on the mud or bare sand they die.

[a] For a more extended account see "Oysters and methods of oyster culture," by H. F. Moore, Bureau of Fisheries Document 349, which may be obtained by application to the Bureau at Washington, D. C.

The natural beds have been slowly developed on bottom similar to that which surrounds them solely because through some agency there originally lodged on the mud or sand some hard objects to which the young oysters could safely cling. Oysters developing there and their shells scattered about by the waves furnished additional places for fixation of new generations of young, with the result that the original growth extended in area and its bed became a compact mass of shells and fragments, beneath which can still be found by excavation or probing the original bottom differing in no essential particular from the adjacent barren areas.

All that is required by the barren bottom in order that it may become productive is that its surface should be supplied with hard objects or cultch, either through natural agencies or by the hand of man. The capacity of the bottom to sustain material deposited on it and to maintain it in proper condition to serve as cultch depends largely on its stability and consistency. Moving sands gradually cover objects deposited on their surface and soft mud permits them to sink. It is therefore of prime importance for the oyster culturist to have information concerning the character of the bottom, and it was one of the purposes of the survey to supply it.

The methods and the instrument employed have been described in the introductory part of this report and the results attained are shown graphically on the chart.

The symbols on the chart designating the character of the bottom do not show all of the places at which examinations were made. They were merely representative of the general characteristics in their vicinity with respect to the bottom deposits. It will be observed that the chart shows, in general, a gradually increasing softness of the bottom toward the middle of the sound. The survey in the adjoining part of Alabama demonstrated that the very soft or oozy mud extends nearly to the islands on the south, adjoining which there is a narrow strip of sand, and, in view of the apparently similar conditions in Mississippi and the limited time at the disposal of the party, it was deemed unnecessary to continue the examinations beyond the line at which it was evident that the bottom was growing too soft for oyster culture.

Excluding the shoal waters near shore, which it is understood are to a considerable extent subject to the control of riparian owners, the firmer bottom lies within five general areas, embracing about 23,000 acres, which are described as follows:

Grand Batture Shoal.—This shoal extends in a curve, concave, toward the east, from the west end of Grand Batture Spit to a beacon in about 8 feet of water near the middle of the sound. The shoal itself lies in a depth of 6 feet or less and is composed of more or less shifting sand, apparently too unstable for oyster culture, but sur-

rounding it, especially between its eastern margin and the Mississippi-Alabama line, the sand is mingled with sufficient mud to give it the required consistency. This firm bottom lies in a depth of between 8 and 12 feet and covers an area of about 4,200 acres. It is fairly well protected from freshets and is of a character which should permit it to be worked with dredges.

Point aux Chenes.—Lying south and southwest of the western half of Point aux Chenes is a strip of stiff and soft mud stretching from the hard sand fringing the shore to a distance of about 1½ miles from land and with a length of upward of 2 miles east and west. Its western extremity is near Beacon B marking the approach to Pascagoula. The depth of water ranges from 6 to 13 or 14 feet and the area of the tract is about 2,000 acres. This bottom is softer than that previously described, but a considerable part of it is suitable for planting either oysters or cultch. Its proximity to the mouth of Pascagoula makes it susceptible to the influences of freshets.

East of Round Island.—Adjacent to Round Island, especially on the east and south sides, is a sandy shoal gradually merging with the surrounding mud. The sandy bottom in depths of less than 5 or 6 feet appears to be shifting, but in the deeper water to the eastward toward the Pascagoula Channel there is sufficient mud to serve as a "binder," and enough sand to correct the excessive plasticity of the mud. In consistency this bottom varies from "hard" to "soft," most of it being what is designated in this report as "stiff." This area, which covers about 1,300 acres, is open to the same objection as the area of Point aux Chenes—its exposure to the effects of freshets owing to its proximity to the mouth of Pascagoula River.

Off Bellefontaine Coast.—From about 1 mile west of the mouth of Graveline Bayou there is a strip of more or less hard bottom stretching almost without interruption to Biloxi Channel, but for convenience of description it appears advisable to divide it at the shoal running from the east end of Deer Island. The portion here described is a curved strip about 5 miles long and from 1 to 3 miles wide encircling the shoal projecting from Bellefontaine Coast. It lies in water from 6 to 11 feet deep and varies in consistency from stiff to soft. In shoaler water the bottom is composed of hard sand liable to shift and in deeper water the mud is too soft. Owing to its proximity to Dog Keys Pass and its relative remoteness from large fresh-water affluents, it is subject to less danger than the preceding two localities in times of flood. It covers an area of approximately 6,500 acres.

Off Deer Island.—This area stretches from the western end of the preceding to the dredged channel leading to Biloxi, outside the sandy area fringing the shore and forming a bar at the eastern end of the island. In depths less than 6 feet the bottom probably shifts more or less under the influence of waves and currents, and is therefore

hazardous for oyster culture, although a few natural growth oysters are found on it in places. In depths between 6 and 9 or 10 feet, and probably somewhat greater, there is a good stiff and soft bottom, most of the area falling within the former classification. Although it is impossible to determine definitely without actual practical experiment, this area, which covers upward of 9,000 acres, appears to be well adapted to oyster culture. The streams discharging in its immediate vicinity are comparatively small, and it is in proximity to Dog Key and Ship Island Passes, therefore being guarded to a considerable extent from destructive reduction of salinity during freshets. The greater salinity might invite the inroads of drills or conchs, but this danger could be somewhat minimized by planting seed oysters rather than cultch.

GENERAL PHYSICAL AND BIOLOGICAL CONDITIONS.

TIDES AND CURRENTS.

During the hydrographic and biological survey tide gauges were maintained at Pascagoula and Biloxi. The former was a plain staff, graduated in feet and tenths, established at the end of the boathouse at the light keeper's house at the mouth of the Pascagoula River. The automatic gauge established by the United States Army engineers was out of order and there was no bench mark available for reference. Mean low water was established by readings from February 7 to March 14, and by comparison with observations made simultaneously during 20 days at Biloxi.

At Biloxi a similar gauge was observed from February 21 to March 12, the mean low water being established by reference to the United States engineers' gauges on channel beacons A and D, which have been referred by leveling to the United States Coast and Geodetic Survey bench mark.

The observations were made primarily for the correction of the soundings, and as the daily tidal range is small, usually about 18 inches, they are of little interest in connection with oyster culture or the fishery. The tidal currents in the region are more or less modified in velocity and duration by the winds, which often mask the lunar tides. In general the currents are sufficient to maintain the distribution of oyster food.

SALINITY OF THE WATER.

The quantity of saline matter in solution in the water is an important factor in determining the growth and character of oysters. If salt be absent entirely, or if its quantity be as great as that carried by the waters of the open sea, oysters will not live, and as these two extremes are approached the adverse effects are seen in the stunted

or otherwise inferior character of the oysters produced. The effects of the salinity of the water are not restricted to the direct influence on the oysters, but may affect them indirectly by furthering or retarding the occurrence of enemies and growths inimical to them. The conch, or drill, for instance, does not thrive in water having a low salt content, while, on the contrary, mussels, the vigorous growth of which is highly detrimental to oysters, often flourish in low salinities.

During the survey the specific gravity of the water was tested thrice daily on the *Fish Hawk* and in addition several observations were made each day by the party actually working on the beds. The following table summarizes the results of these observations:

SPECIFIC GRAVITY OF WATER AT VARIOUS PLACES AND DATES.

Locality.	Date.	Average temperature.	Average specific gravity.	Maximum specific gravity.	Minimum specific gravity.
	1910–11	°F.			
Off Point aux Chenes	Feb. 9–11	63	1.0190	1.0204	1.0164
	Feb. 14–16	67	1.0170	1.0194	1.0129
Pascagoula, Miss	Dec. 24–27	49	1.0196	1.0209	1.0187
	Jan. 20–24	61	1.0122	1.0154	1.0106
	Jan. 29–31	65	1.0169	1.0188	1.0152
	Feb. 1–4	67	1.0121	1.0156	1.0063
	Feb. 5–8	71	1.0136	1.0173	1.0075
	Feb. 12–14	61	1.0136	1.0180	1.0084
	Mar. 6–8	66	1.0168	1.0178	1.0139
	Apr. 2–4	70	1.0152	1.0190	1.0140
Three miles south of Graveline Bayou	Feb. 16–18	68	1.0175	1.0194	1.0133
	Mar. 13–14	65	1.0209	1.0210	1.0208
Three miles off Biloxi Bay	Feb. 19	70	1.0178	1.0207	1.0138
Three miles southwest of Deer Island	Mar. 4–6	63	1.0189	1.0196	1.0182
	Mar. 8	69	1.0198	1.0212	1.0184
	Mar. 11–13	71	1.0193	1.0203	1.0187
Biloxi	Feb. 20–23	54	1.0151	1.0177	1.0118
	Feb. 24–27	58	1.0150	1.0156	1.0129
	Feb. 28–Mar. 3	63	1.0170	1.0186	1.0127
	Mar. 9–10	68	1.0187	1.0192	1.0182

This table embraces observations made at intervals between December 24, 1910, and April 4, 1911, part of the period, from January 20 to March 10, being covered with practically no interruption. During this time the specific gravity varied from a maximum of 1.0210 off the mouth of Graveline Bay on March 14 to a minimum of 1.0063 at Pascagoula on February 4, and the local averages for periods of several days ranged with time or place between 1.0209 off Graveline Bayou on March 13 and 14 to 1.0121 at Pascagoula on February 1 to February 4. These figures compare with fresh water as 1.0000 and ocean water as 1.0250 or 1.0260. The minima shown in the table all occurred at low water and the maxima at or near high water. The lowest readings were taken in Pascagoula River, the station being located at the railroad bridge, where there was a considerable difference between the salinity of successive high and low waters. The highest average, as well as the lowest daily fluctuation,

was found off Deer Island, near Biloxi. Nowhere during the survey was the salinity above or below that which oysters will tolerate, although in Pascagoula River it sometimes fell below that at which good marketable stock is ordinarily produced. In times of prolonged and very heavy rainfall undoubtedly the water in Pascagoula River becomes entirely or practically fresh, and the influence of its discharge must be felt in a pronounced reduction of the salinity of the sound near its mouth.

OYSTER FOOD.

In reports on previous surveys a feature usually has been made of the subject of the quantity of oyster food carried by the waters. These discussions have been confined, practically, to diatoms, minute microscopic plants, which authors generally have been prone to regard as supplying practically all of the oyster's nutriment. Volumetric studies of the micro-organism content of the water begun in connection with the survey of Matagorda Bay [a] in 1905 revealed a quantity so small as to excite the author's suspicion that the living matter was of less relative importance than had been generally supposed.

It appeared possible, however, that the quantity of water filtered by the oyster might be greater than generally supposed and digestion more rapid, and that despite appearances the small quantity of microscopic living organisms in the water and present in the stomach at any one time might be sufficient material for the growth and general physiological activities of a sluggish animal like the oyster.

To test the matter, apparatus and methods [b] were devised for the volumetric determination of the organisms actually eaten during comparable periods of time. The result of this work, which has been carried on at intervals for several years by the author and Mr. T. E. B. Pope, has shown that while the quantity of water filtered is great, averaging roughly about 30 quarts daily for oysters 4½ inches long, the volume of the living food is insufficient to account for the actual growth of the oyster, making no allowance for the requirements of other vital activities. It appears that finely divided organic debris or detritus, which constitutes the major part of the material ingested, plays a more important role in the oyster diet than has been conceded, a view which recently has been advanced by Petersen and Jensen.[c]

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[a] Survey of oyster bottoms in Matagorda Bay, Tex. By H. F. Moore. Report of the Bureau of Fisheries, 1905. Bureau of Fisheries Document No. 610.

[b] Volumetric studies of the food and feeding of oysters. By H. F. Moore. (Proceedings of the Fourth International Fishery Congress, Washington, 1908.) Bulletin, Bureau of Fisheries, vol. XXVIII, 1908, pp. 1295–1308.

[c] Valuation of the sea. I.—Animal life of the sea bottom, its food and quantity. By C. G. Joh. Petersen and P. Boysen Jensen. Report of the Danish Biological Station, XX. Copenhagen, 1911.

In view of these facts and probabilities, and the present impossibility of establishing a standard for the expression of the quantity of food available, the data respecting the food content of the water collected during this survey will not be stated here. A special paper on the entire subject of the food and feeding of oysters will be issued on the completion of the studies.

It may be stated from observation of the oysters and on general grounds that the food supply in Mississippi Sound and minor contiguous waters is ample.

OYSTER ENEMIES.

As the survey was carried on during the early spring, when the water was still comparatively cold, the observations made are probably not to be regarded as a reliable index to the abundance of oyster enemies. None were observed but a few drills, mostly small, and an insignificant number of mussels. The low temperature of the water could have had but little effect on the latter, and it is fair to assume that ordinarily they are nowhere present in sufficient numbers to prove seriously detrimental to the oysters.

As observations on other parts of the Gulf coast have shown that certain enemies to the oyster are of general occurrence, it appears advisable to furnish some general information respecting them.

Drill, borer, snail, whelk, conch (Purpura hæmostoma).—This animal, which bears these several names on the Gulf coast, was found very sparingly during the survey in Mississippi waters, and there was little other indication of its presence. A few small ones were taken on Scranton Reef and in Biloxi Bay, but in neither place was there found a sufficient number of drilled oyster shells to indicate that it had been recently abundant. It is liable to occur, however, especially in the more saline water, and care should be exercised not to introduce it with seed oysters from infested beds.

The drill or whelk lays its eggs in red or purple leathery capsules about one-half inch long and attached in clusters to shells, snags, and other firm bodies in the water. The young become destructive to the minute spat immediately upon emerging from the egg cases; they grow rapidly and progress in destructiveness as they increase in size. They destroy the oysters by drilling a small round hole through the shell, using for the purpose a flexible rasp-like organ lying at the end of a protrusible proboscis. After the shell is perforated the proboscis is thrust into the shell and the contents eaten, other drills sometimes partaking of the feast by entering the gaping shell of the dead or dying oyster. Most of the oysters destroyed are under 2 inches long, but large drills often kill more adult oysters.

Mussels.—The common black sea mussel is a passive enemy of oysters, through its tendency to attach to them and under favorable

conditions to grow so rapidly and in such numbers as to completely cover and stifle them. Also, as its food is the same as that of the oyster, its abundance reduces the supply and in that way deprives the oyster of the nutriment required to make it fat and marketable. Even when neither of these effects are important, mussels injure the fishery, owing to the tenacity with which they are anchored to the oyster, which increases the labor of culling and makes the oyster so unsightly from the adhering fibers of the byssus as to considerably reduce its market value if sold as shell stock. The conditions which make for the abundance of the mussel are not thoroughly understood, but on the Gulf coast it appears to be controlled largely by the saltness of the water, the mussels generally flourishing where the salinity is low for prolonged periods. Comparatively few were found in the region surveyed, and it is probable that they never or rarely become troublesome on account of the high salinity frequently occurring.

Drumfish (*Pogonias cromis*).—This, the "black drum," was not observed during the survey, but it is a destructive enemy of the oyster in other parts of the Gulf coast and is reported to destroy oysters on the adjacent beds of Alabama. It is migratory, making sudden forays and leaving, with destruction in its wake, often before its presence has been noticed. It destroys the oysters by crushing them between the stout grinding teeth or bones with which its mouth is furnished, and it is peculiarly destructive to the better grade of planted beds on which the oysters have been culled and separated to permit them to grow and improve in shape and quality. It is especially likely to attack the culled oysters within a few weeks of the time when they are planted, but they are not immune at any time. In Louisiana the drumfish is so destructive in places that the oystermen find it necessary to exclude them by surrounding their bedding grounds with wire fences.

Oysters in the natural beds, especially when they are much clustered and of the sharp-edged raccoon type, are rarely injured seriously, as the sharp edges of the shells, presented in all directions, lacerate the lips and mouth of the fish and deter them from extensive destruction. Occasionally the small oysters culled off by the oystermen are damaged.

The drumfish occurs in waters of all degrees of salinity, from fresh or practically fresh to full oceanic density.

SPAWNING.

The survey was conducted at the season when the reproductive functions of the oysters are in abeyance, and therefore no definite statement of the spawning season in Mississippi can be made. Various investigations carried on by the Bureau at the western end of

Mississippi Sound, where the general conditions affecting spawning are essentially the same as at the eastern end, make it possible to indicate with some precision the period during which the spawn is likely to be emitted.

It is probable that the eggs may ripen even in the winter during sustained warm periods, but it is doubtful in these cases, even though the eggs be fertilized, if development ever proceeds far enough to secure a set of spat. The normal spawning probably occurs from April to October, as it does in similar waters in Louisiana, and clean shells or other cultch planted during those months should receive a good set of spat. The young oysters are free-swimming organisms during a short period of their early life, and as they are produced in untold myriads on the crowded natural beds and carried considerable distances by the currents, the water over a large part of the sound must be teeming with the fry during the favorable part of the year. Most of these embryo oysters perish through falling on unsuitable bottom at the stage of the shell formation when they are still barely visible to the unaided eye, and may be stifled by an exceedingly thin deposit of mud or slime. Those fortunate enough to alight on shells or other oysters and similar firm supports survive in large numbers, as is witnessed by the crowded condition of the beds, but over the vastly greater proportion of the bottom there is nothing to afford a haven. The only fundamental difference between an oyster bed and the surrounding barren bottom is that the former presents places for the attachment of the spat and the latter does not.

Many free-swimming oyster fry are also killed by sudden drops in temperature, though this is not common on the Gulf coast, and by heavy rainfalls. The latter also tend to retard or suspend spawning through lowering the salinity of the water, and it frequently happens that heavy freshets defer spawning until summer. As freshets usually leave the shells and other cultch in excellent condition so far as cleanliness is concerned, probably through the destruction of slime-producing organisms, it frequently happens that a late spawning season produces an enormous set.

OYSTER CULTURE.

Oyster culture in the sense employed on the Atlantic and Pacific coasts and in some of the Gulf States is almost negligible of consideration, as at present practiced in Mississippi. The State conducts planting operations on the public bottoms, expending large sums annually during the years 1908 to 1911 in depositing oysters and shells on the reefs and adjacent barren bottoms, but there is very little oyster planting under private auspices, and none at all excepting under rights accruing to riparian owners. In 1911, but 4 per cent of the oysters produced in the State came from private beds, a smaller

proportion than in any other Gulf State excepting Texas. In Louisiana, in the same year, 44 per cent of the oysters produced were grown on bottom rented from the State, and the yield from this source alone was three times the quantity, and over four times the value, of the entire product of Mississippi.

Most of the planting by the State was west of the region covered by the survey, but large quantities of shells and oysters have been deposited on Scranton Reef and the Biloxi Bay beds, the condition of which was developed during the present investigation, and is presented in some detail in the preceding part of this report. It is the opinion of the author that the survey developed the almost complete futility of the State's policy so far as the region east of Biloxi is concerned. Pascagoula or Scranton Reef, and West Pascagoula Reef were practically worthless as market oyster producers during the winter and spring of 1910–11. During a considerable period of observation no boats, excepting one or two small skiffs, were seen on the former, and but one schooner on the latter. The oysters were badly clustered, ill shaped, and poor in every way. During the calendar year 1911 about 28,000 bushels of oysters were taken by small boats from the vicinity of Pascagoula. Some of these came from the Pascagoula River, where they are of good quality, and the remainder are reported to have come from the adjacent reefs.

In Biloxi Bay the conditions are somewhat better, but still poor. Deer Island bed produces fairly good oysters, but on all of the other beds the stock was rough, clustered and generally inferior, although the presence of a number of tongers on the large bed below the railroad bridge and on the east bed above the bridge indicates that it finds some market.

The laws of Mississippi do not permit the lease of barren bottoms for oyster culture, but in its report for 1911 the Board of Oyster Commissioners recommended "that they be given the right by law to lease to private individuals, firms, and corporations, citizens of the State, for a term of years to be fixed by the legislature, barren bottoms suitable for planting oysters, on such terms and at such prices as the legislature may fix." With this recommendation the author is in hearty accord, but he believes that the further suggestions that the extent of the leaseholds be limited to 100 acres for each person, firm, and corporation, and that the annual rental be fixed at $1 per acre are not sufficiently liberal. Although this survey indicates that in the region covered upwards of 23,000 acres of the bottom are presumptively suitable for oyster culture, it should be remembered that until practical test is actually made there is no conclusive evidence that they are suited for the purpose. For this reason the first plantings must be in the nature of experiments with the possibility of failure. In view of this, and to induce the undertaking, the rental

during the first few years should be low, gradually increasing to a maximum of $1 per acre after time has been granted for the determination of the commercially feasibility of the project under any given lease. If the practicability of private oyster culture should be demonstrated it would then be advisable to permit a somewhat larger holding than 100 acres, so as to remove any inclination to plant too thickly and thus cause deterioration of the stock.

Doubtless the point will be raised that if the State's planting operations have been less successful than was hoped, the same result will accrue in respect to private undertakings. This does not follow. It is well known that a tenant is usually less careful of the soil than is the owner of a farm, and that a municipality always manages its affairs less efficiently than a private individual or corporation. Abundant experience has shown, as a knowledge of human nature would lead one to predict, that private oyster beds are more carefully and successfully managed than are public ones. They produce more, and the oysters are better. In Mississippi, in 1911, the average price of plants was twice that of oysters from the public beds, and general experience has shown that the better and higher-priced oysters can find a market when the inferior, low-priced stock is begging for a buyer.

Oyster culture consists of more than throwing a lot of oysters or shells on an old reef or tract of barren bottom. The planted material must be properly distributed with due regard to the character of the bottom, and seed oysters must be properly separated from the natural clusters, else they will crowd one another as they grow, many of them will die and the survivors be poor in shape and quality. If through growth and subsequent sets of spat they become too dense on the bottom, they must be judiciously thinned and transplanted, and they must be guarded as much as possible from enemies and from persons taking them illegally. A private planter hoping to reap the reward of his care and industry will see to these things, but the public in dealing with a common property is indifferent, or worse, and the results are unsatisfactory even though the State may spend considerable sums to make it otherwise.

Aside from its production of much-needed foodstuff and its increase in the wealth production of the body politic as a whole, which are the important considerations, oyster culture has the additional advantage of economy in State administration. The care of the public beds is a constant avenue of State outlay. The leasing of barren and naturally unproductive bottom is a source of State revenue.

In all States in which there are natural beds of considerable expanse the major part of the expenditures of oyster-law administration are in their behalf. The production of revenue is not the chief concern when the welfare of industry and the conservation of a food supply

are concerned, but when the people of the State at large are called on to pay the bills, in whole or in part, it is a legitimate and proper subject for consideration.

Finally, the welfare of the public beds and of those obtaining a livelihood from them is not threatened by the encouragement of oyster culture, as with respect to them there need be no change in the policy of the State. If care be taken to exclude the natural beds from leasing, it is probable that they even may be benefited by oyster culture on the barren bottom, and it is reasonably certain that, as has been the case in other parts of the country, a number of those now working on them will become oyster planters if opportunity be given them, thus replacing their present more or less precarious and uncertain livelihood by a more assured and regular as well as more profitable calling.

It is not necessary to discuss in detail the methods of oyster culture, as a special pamphlet[a] on the subject may be obtained on application to the Bureau of Fisheries. It appears advisable, however, to indicate briefly the two general methods open to prospective oyster growers in Mississippi, the planting, or more properly transplanting, of young oysters from the natural or other beds and the deposit of shells or similar materials to which the spat may attach.

As has been shown in the preceding pages, certain of the beds are so densely crowded with small oysters that few of them have chance to develop into marketable stock. Transplanting a considerable number of these from judiciously selected places to barren bottoms should not only result in saving a considerable proportion of the plants but would improve the living conditions of those left on the reefs and permit them therefore to become as good as is possible under their environment. For ordinary cannery purposes the seed oysters would require but rough culling, but if it is desired to produce oysters for shucking or shell stock the clusters should be well broken up, so that the individuals are not at all crowded as they grow. It is not necessary to separate them into single oysters, and where the drumfish is likely to occur it is advisable not to do so. In general, it is desirable to plant seed oysters at least 2 inches long in the more salt water where the drill is found, as those of smaller size and thinner shells are likely to be killed. For the same reason spat setting on the shells rarely survives in drill-infested regions, and the culled seed is not likely to become overgrown with many young. Should oyster culture reach considerable magnitude in the State, or the natural beds become depleted of superfluous young, it will be necessary to resort to shell or other cultch planting to secure a set of spat. This should be conducted in the fresher waters where the drill is least likely to be found, and the material planted, in order to prevent the formation of large clusters, should be in as small pieces as will suffice as collectors.

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[a] Oysters and methods of oyster culture. By H. F. Moore. Bureau of Fisheries Document No. 349.

The section of this report dealing with the barren bottoms, together with the chart, should be consulted for the location of areas on which experiments in oyster culture may be undertaken with some assurance of success. The regions off Deer Island and east of Grand Batture Shoal are probably the most promising. On each of these the depth and the character of the bottom are such that the beds could be worked with light dredges, and both appear to be adapted to the growth of oysters from seed. The work should be conducted as an experiment in the beginning, and not on a scale so large as to entail heavy loss if some of the conditions should unexpectedly prove unfavorable.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

The following pages briefly review the conditions developed by the survey, with the deductions and recommendations based on them.

1. The survey included that part of Mississippi Sound lying between the Alabama-Mississippi boundary and Biloxi, being practically restricted to the County of Jackson, although including a small part of Harrison County in the vicinity of Biloxi.

2. Within these limits there are embraced natural beds aggregating about 1,708 acres, of which 475 acres, classed as bearing dense and scattering growth, bear oysters of marketable size in sufficient quantities to support a fishery. On part of this area, however, the quality was too poor at the time of the survey to permit the oysters to find a ready market at a remunerative price. On the remaining 1,233 acres large oysters are too scattered to be taken commercially with profit.

3. It is estimated that in February and March, 1911, these beds contained not less than about 120,000 bushels of oysters over 3 inches long and about 375,000 bushels of smaller ones, a total of not less than 495,000 bushels of oysters of all sizes. Of this quantity, about 80,000 bushels of the larger size and an equal quantity of the smaller ones were on those parts of the beds in which the former were present in sufficient density of growth to warrant a commercial fishery. The bushel measure used was the standard employed in the State, and as the oysters were culled into singles and doubles and compactly arranged, the measure contained a larger number of oysters than is usual in commercial practice. The data furnished is therefore conservative as to the content of the beds.

4. The quantity of small oysters on the beds as a whole is largely in excess of the quantity of large ones, although on the denser areas of market oysters in Biloxi Bay this is not the case. As, however, it requires a larger number of small oysters to produce a given quantity, the small oysters are nearly everywhere numerically equal to or in excess of the large ones, the only exceptions being on some of the

scattering growth areas of Biloxi Bay. On the parts of the beds where the large oysters are most abundant the numerical proportion of small oysters to large ones ranges from equality on the small patches in Biloxi Bay to about 17 to 1 on West Pascagoula Reef. Where the larger oysters are fewer the proportion is generally higher, reaching about 228 to 1 on the so-called depleted part of West Pascagoula Reef, where marketable oysters are practically absent. The young oysters are, therefore, present on practically all of the beds in sufficient numbers to insure the continuance of the present content of market oysters, and the production of some of the beds, especially those in the vicinity of Pascagoula, should be increased by a judicious removal of some of the young.

5. The demand for oysters in Mississippi is in excess of the present supply of good stock. While some of the natural beds in the region east of Biloxi may be improved by rational treatment, it is not believed that they can fill requirements. They may supply some of the demand for cannery purposes, which do not require the highest quality, but they can not satisfactorily fill the demand for the shucking and shell trade.

6. To satisfy this demand for an increased supply, and especially for a better quality than the natural beds produce, the State should enact such legislation as will permit and encourage commercial experiments in oyster culture on the present barren bottoms. There are within the limits of the survey upward of 23,000 acres of bottom, now worthless but apparently suitable in stability and other requirements for oyster culture. These bottoms, if experiment should confirm favorable opinion as to their utility, constitute a valuable asset of the State now wasted for lack of legal authority for their rental. This defect in the oyster laws should be corrected.

7. The Gulf coast in general has advantage over the more northern oyster-producing States in its milder climate, which is less likely to impose interruption to the fishery. It has the disadvantage of affording a somewhat shorter season, owing to the shorter term of cool weather in which oysters can be handled without spoiling. In respect to transportation to a large part of the interior population, it is more favorably situated than are the States of the Atlantic seaboard. It should also have some advantage in the shipment of seed oysters to a considerable part of the Pacific coast.

8. The production of spat is more to be depended on than in the great oyster-producing States of the North, in some of which the set is liable to fail for several years in succession, entailing serious loss on the planters. Moreover, growth is in general more rapid, and marketable oysters are produced in half the time required on some of the northern grounds.

9. Oyster enemies are no more destructive than are those of the North, and some of the worst of the latter do not cause trouble on the Gulf coast. Disaster from freshets is more likely to occur, but can be, to a considerable extent, guarded against by judicious choice of location.

10. One of the most serious difficulties with which planters and oystermen have to contend, the pollution of the public and private beds by drainage and sewage discharges, is minimized by the absence of large communities adjacent to the oyster bottoms. Private beds producing oysters for the market should not be located in proximity to sources of contamination, and floating or "fattening" oysters by immersion in fresh water should be discouraged and absolutely prohibited if the water used be open to suspicion of pollution. The future of the oyster industry everywhere depends in large measure on the guarantee of its product in respect to cleanliness and wholesomeness, and not only the State oyster commissions and boards of health but the oystermen themselves, for both moral and business reasons, should require that the public health be safeguarded from the acts of the careless and unscrupulous.

11. Should a law be passed authorizing the leasing of the barren bottoms, such leaseholds as are granted should be carefully surveyed to determine their areas, the tracts should be regular in shape, and the corners located by reference to the triangulation stations or landmarks established by the Coast and Geodetic Survey. These are all carefully determined and are permanently marked, and a strict compliance with this recommendation will guarantee accuracy in the surveys, obviate disputes, and secure an honest and correct assessment of rental.

12. Legislation to secure these ends should be carefully drawn and based on the experience of States in which oyster planting has been successful from the standpoints of the planters and the State as a whole.

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OYSTERS FROM SCRANTON REEF.

(Natural size.)

OYSTERS FROM WEST PASCAGOULA REEF.

(Natural size.)

OYSTER FROM DEER ISLAND BED, BILOXI BAY.

(Natural size.)

OYSTERS FROM SMALL PATCH, BILOXI BAY.

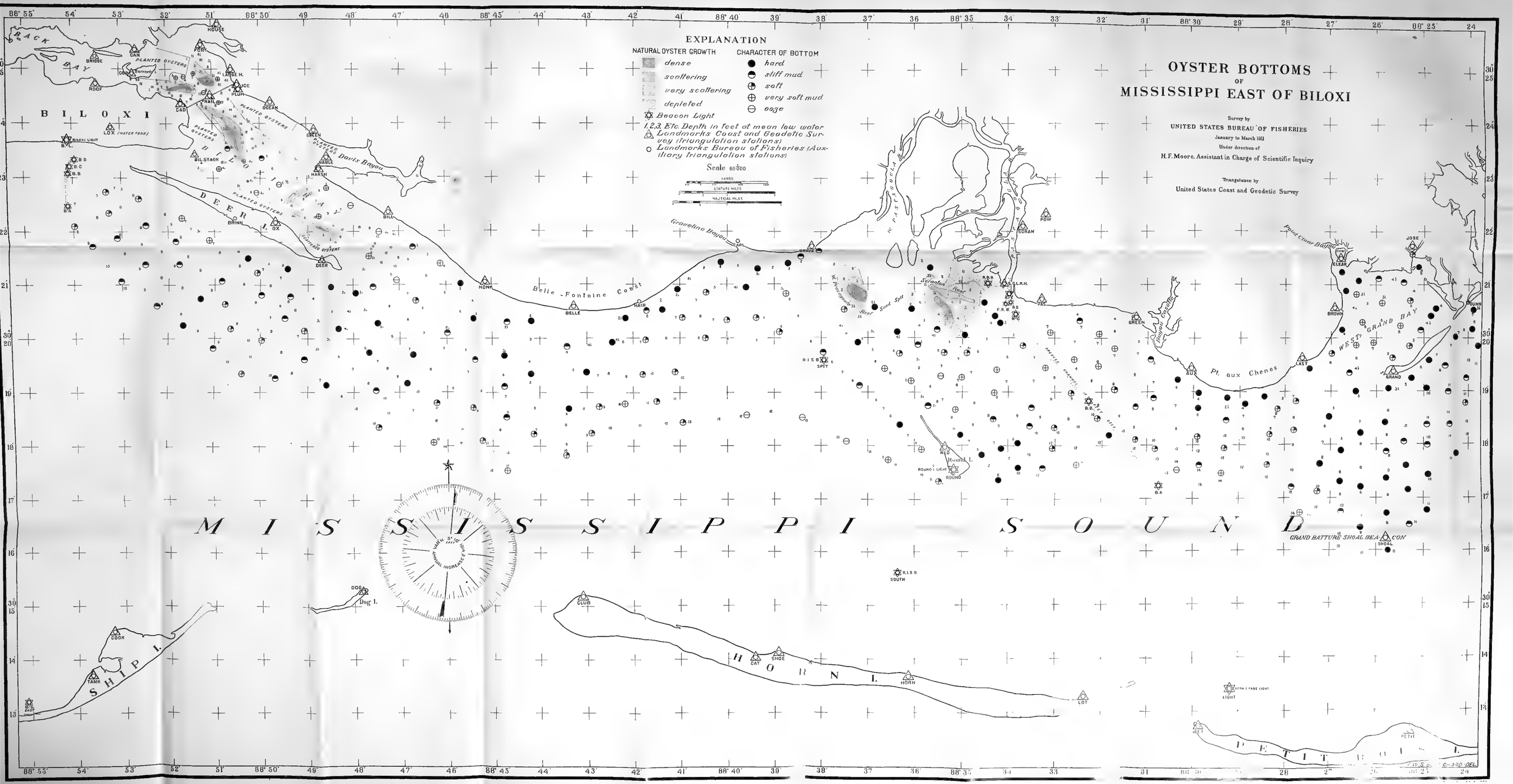
(Natural size.)

OYSTERS FROM LARGE BED, BILOXI BAY.

(Natural size.)

OYSTERS FROM BACK BAY, BILOXI.

(Natural size.)


EXPLANATION
NATURAL OYSTER GROWTH
dense
scattering
very scattering
depleted
CHARACTER OF BOTTOM
hard
stiff mud
soft
very soft mud
ooze
Beacon Light
1,2,3, Etc. Depth in feet at mean low water
Landmarks Coast and Geodetic Survey (triangulation stations)
Landmarks Bureau of Fisheries (Auxiliary triangulation stations)
Scale 60000
YARDS
STATUTE MILES
NAUTICAL MILES
OYSTER BOTTOMS
OF
MISSISSIPPI EAST OF BILOXI
Survey by
UNITED STATES BUREAU OF FISHERIES
January to March 1911
Under direction of
H.F. Moore, Assistant in Charge of Scientific Inquiry
Triangulation by
United States Coast and Geodetic Survey
BACK BAY
BILOXI
PLANTED OYSTERS
Davis Bayou
DEER I.
Gravelline Bayou
Belle Fontaine Coast
W. Pascagoula Reef
Sand Spit
Seranton Reef
Point Clear Bayou
Grand Bay
West Grand Bay
Pt. aux Chenes
Grand Batture Shoal Beacon
MISSISSIPPI SOUND
Dog I.
SHIP I.
HORN I.
PETIT BOIS I.
Round I.
MAGNETIC VARIATION 5° 10' WEST (1911.0)
ANNUAL INCREASE 6'

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